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Distributions and Habitat Associations of Birds in Waikiki, Hawaii

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ABSTRACT: We conducted 57 transects along three routes in Waikiki from August through December 1986. Rock Doves, Zebra Doves, and House Sparrows, all alien species, accounted for approximately 80% of all birds observed. All three species were most common near the Honolulu Zoo and Fort DeRussy Beach Park. Distributions of all three species were significantly correlated with decreasing distance from the Honolulu Zoo, increasing human densities, and parklike habitats. Effects of distance, human density, and habitat characteristics were separated using multiple regression analysis. Rock Dove distributions were primarily affected by distance from the Honolulu Zoo, a major feeding and roosting site for Rock Doves. House Sparrow distributions were primarily affected by human densities, and secondarily by habitat characteristics. Zebra Dove distributions were primarily related to habitat characteristics.

ECONOMIC GROWTH and associated land development has accelerated dramatically in the central Honolulu and Waikiki areas over the past two decades. This has increased the amount of urban and suburban habitats in southeastern Oahu, a factor that has been implicated in an increase in the rate of naturalization and range expansion of several exotic bird species during the 1970s (Williams 1987). Native bird species are absent from these habitats (Pyle 1986) and many exotic or alien bird species are either absent or occur infrequently in urban environments. However, several alien species that are recognized as commensal with humans (Weber 1979), including the Pigeon or Rock Dove (*Columba livia*), Zebra Dove (*Geopelia striata*), and House Sparrow (*Passer domesticus*), occur in their highest densities in Waikiki (Pyle 1986). Indeed, these three species account for approximately 80% of all birds occurring there (Fleischer and Williams 1987).

Waikiki is regularly used by Hawaii residents, as well as visitors, for business and recreational pursuits. Because birds and humans are both concentrated in Waikiki, the possibility exists for negative interactions (e.g., transmission of disease, property damage, etc.) to occur between them. However, basic ecological information on the distributions and habitat associations of birds in Waikiki is required before any assessment of possible interactions can occur.

In this paper, we present ecological information on the distributions of House Sparrows, Rock Doves, and Zebra Doves throughout Waikiki and Kapiolani Park. These species have a long history of association with humans and are generally recognized as pests (Long 1981). We discuss associations of these three species with human densities and habitat characteristics. Finally, we discuss the biological implications of attempting to manage these alien bird populations.

History and Ecology of Bird Species

ROCK DOVE. Rock Doves, native to the Mediterranean region of Europe, were introduced to Hawaii in 1796 (Walker 1967), probably as an escape from domestication.

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Hawaii Audubon Society (1975) noted that Rock Doves were found on all islands, with a predominantly white form occurring throughout Waikiki and Kapiolani Park. These white Rock Doves are apparently the descendents of four pairs of "White Kings," a domesticated strain favored by pigeon fanciers, which were released at the Honolulu Zoo (Go 1973).

Our recent field work (Fleischer and Williams 1987) shows high levels of human–Rock Dove interactions in the Waikiki–Kapiolani Park area, especially at the Honolulu Zoo, where many families picnic with small children.

HOUSE SPARROW. The House Sparrow is native to Eurasia and North Africa and is probably the most widely and successfully introduced bird in the world (Long 1981). All House Sparrows in Hawaii are believed to have descended from nine sparrows imported from New Zealand in 1871 (Caum 1933). Although House Sparrows are found on all major Hawaiian islands, they are restricted primarily to cities and rural areas around human habitation and have not had the widespread success they have had elsewhere in the world. Nevertheless, House Sparrows are abundant in open-air restaurants throughout Waikiki (Fleischer and Williams 1988).

ZEBRA DOVE. Several races or subspecies of Zebra Doves, which are native to southeast Asia and Australia, were introduced to Hawaii in 1922. They are currently the most common bird on Oahu (Pyle 1986). Zebra Doves are not considered pests in Hawaii, with the possible exception of the Waikiki area where concentrations of them occur in association with humans at picnic areas and at open-air restaurants (Fleischer and Williams 1988).

MATERIALS AND METHODS

We conducted 57 censuses along three transect routes in Waikiki from 5 August until 19 December 1986. Transects were located along Ala Wai and Kuhio avenues and along portions of the Waikiki beachfront and Kalakaua Avenue (Figure 1). Transects encompassed

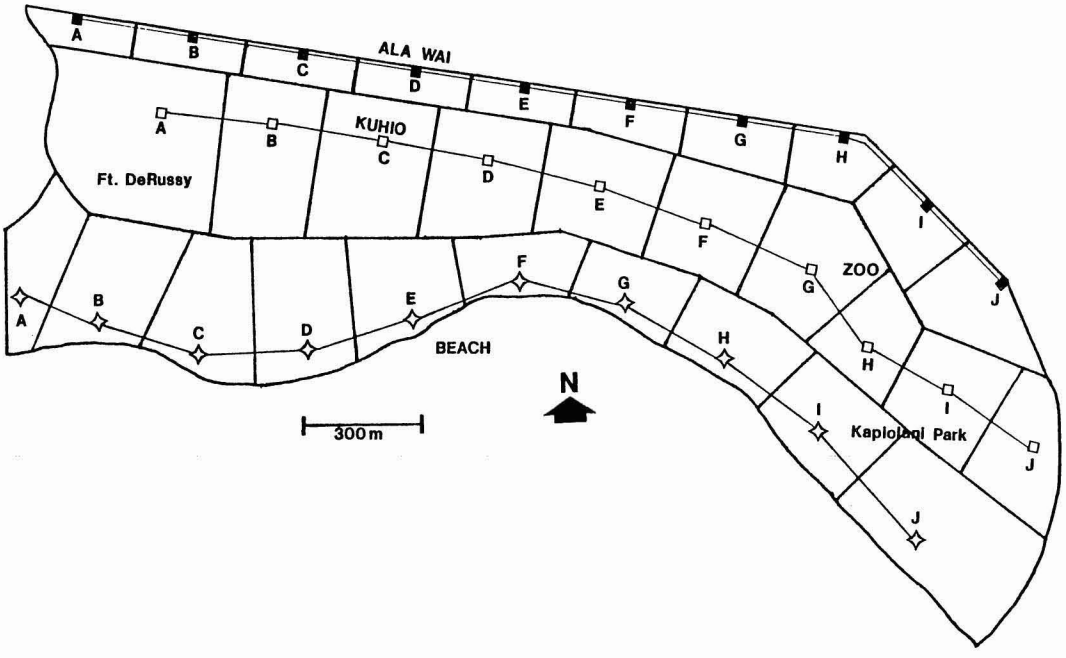

FIGURE 1. Map of Waikiki study area noting transect stations along Ala Wai Boulevard, Kuhio Avenue, and the Waikiki beachfront.

Kapiolani Park, the edge of the Honolulu Zoo, and both urban and beachfront areas of Waikiki. Each transect was 2.7 km in length and had 10 equally spaced (0.30 km) sampling stations.

Transect censuses began at four different times of the day: 0630, 1000, 1400, and 1630 hours HST. Counts were randomized for date, time of day, direction along transect, and observer. Counts at each sampling station were conducted within the confines of a 30-m radius circle. A 1-min initial count period was used to assess human density in the sampling circle on a categorical scale (0 = 0 people, 1 = 1–5, 2 = 6–10, 3 = 11–25, 4 = 26–100, 5 = >100). Birds were subsequently counted over a 5-min period. Each transect took approximately 2 hr to census.

We also recorded habitat characteristics for each transect and sampling station once during the latter portion of the study. We used a categorical relative abundance scale to estimate the amount of grass, bushes, shrubs, trees, palms, sand/concrete, buildings (0 = 0–5%, 1 = 6–25%, 2 = 26–50%, 3 = 51–75%, 4 = 76–95%, 5 = 96–100%), and building height (0 = none, 1 = 1–2 stories, 2 = 3–7, 3 = 8–15, 4 = 16–30, 5 = >30) within each count circle. Categorical data values for each of the above parameters were assigned using a percentage cover estimate, where 100% represented the maximum density observed for that specific parameter along all three transects.

Transect census data were then used to determine avian community structure in Waikiki and to compute correlations of bird densities with human densities and habitat characteristics.

RESULTS

Transect Censuses

SPECIES COMPOSITION. House Sparrows, Rock Doves, and Zebra Doves accounted for 79.2% of all birds observed during transect censuses in Waikiki (Figure 2). Inclusion of Common Mynas (*Acridotheres tristis*) and Spotted Doves (*Streptopelia chinensis*) raised the cumulative total to 94.0%. Eleven additional species made up the remaining 6.0%: Red-crested Cardinal (*Paroaria coronata*), Northern Cardinal (*Cardinalis cardinalis*), Red-vented Bulbul (*Pycnonotus cafer*), Red-whiskered Bulbul (*P. jocosus*), Japanese White-eye (*Zosterops japonicus*), Yellow-fronted Canary (*Serinus mozambicus*), Java Sparrow (*Padda oryzivora*), Golden Plover (*Pluvialis fulva*), White Tern (*Gygis alba rothschildi*), and Great Frigatebird (*Fregata minor palmerstoni*).

SPECIES DISTRIBUTIONS. Distributions of the mean numbers for each species along the three transects are presented in Figure 3. House Sparrows (Figure 3*a*) were common along the beach transect and abundant in all three transects near the Honolulu Zoo and adjacent areas of Kapiolani Park and Jefferson School. House Sparrows were also concentrated on the beach transect at the Fort DeRussy Beach Park (stations B and C).

Rock Doves (Figure 3*b*) had a similar distribution to that of House Sparrows, with highest concentrations along the beach and near the Honolulu Zoo and Fort DeRussy Beach Park. Rock Doves were by far the most abundant bird near the Honolulu Zoo (Figure 3*b*, stations H and I) with feeding flocks of several hundred birds common in the zoo interior and on the expansive lawn between the Zoo and Waikiki Beach (corner of Kapahulu and Kalakaua avenues). Although widespread throughout Waikiki, Rock Doves occurred in low concentrations along the urban portions of the Ala Wai and Kuhio transects, as compared to House Sparrows (Figure 3*a*) and Zebra Doves (Figure 3*c*).

Like House Sparrows and Rock Doves, Zebra Doves (Figure 3*c*) were most common near the Honolulu Zoo and Fort DeRussy Beach Park; however, they were relatively more abundant and widespread throughout the remainder of Waikiki than Rock Doves. Except for the parklike Zoo and Fort DeRussy areas, Zebra Doves occurred in nearly equal numbers along the beach and Kuhio transects and in reduced numbers along the Ala Wai transect.

HABITAT CORRELATIONS. Principal components analysis was performed on the eight

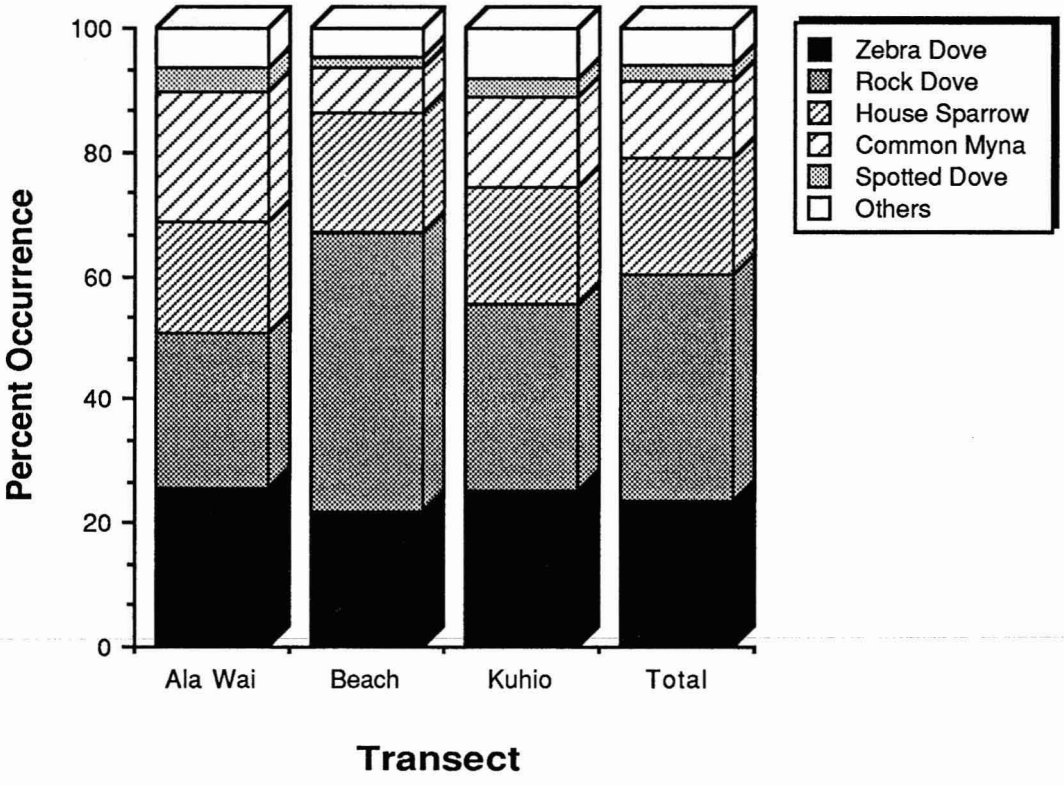

FIGURE 2. Species composition for birds along three transects in Waikiki and for combined data.

habitat variables (Table 1) as a method of reducing them to a smaller number of summary variables. Eight principal component scores and eigenvalues were calculated. Nearly half (48.8%) of the variability in habitat characteristics was accounted for by the PC-1 score, while PC-2 and PC-3 accounted for 16.6% and 12.3% of the additional variation, respectively.

The eigenvectors of PC-1 (Table 2) indicate a contrast between the amount of concrete, number of buildings, and building height versus the amount of grass and trees. Thus, PC-1 was viewed as an axis with highly urbanized habitats at the one end and parklike habitats at the other. PC-2 and PC-3 did not account for a large proportion of the variance and were also not clearly interpretable (Table 2). House Sparrows, Rock Doves, and Zebra Doves showed a significant ($P < 0.01$; Table 3) negative relationship between mean numbers of birds and positive PC-1 scores (i.e., high levels of concrete, buildings, and building height). Thus, all three species were most common in parkland habitats where trees and grass were abundant. PC-2 and PC-3 were not significantly correlated with densities of any of the bird species.

HUMAN DENSITY CORRELATIONS. Mean human density scores (Table 1) at each transect and sampling station were related to mean bird numbers (Table 1) for each of the three species. Human density was significantly and positively correlated ($P < 0.001$) with mean bird numbers for all three species (Table 3).

CORRELATION WITH DISTANCE FROM HONOLULU ZOO. The relationship between mean numbers of birds at each transect sampling station and distance of the station from the

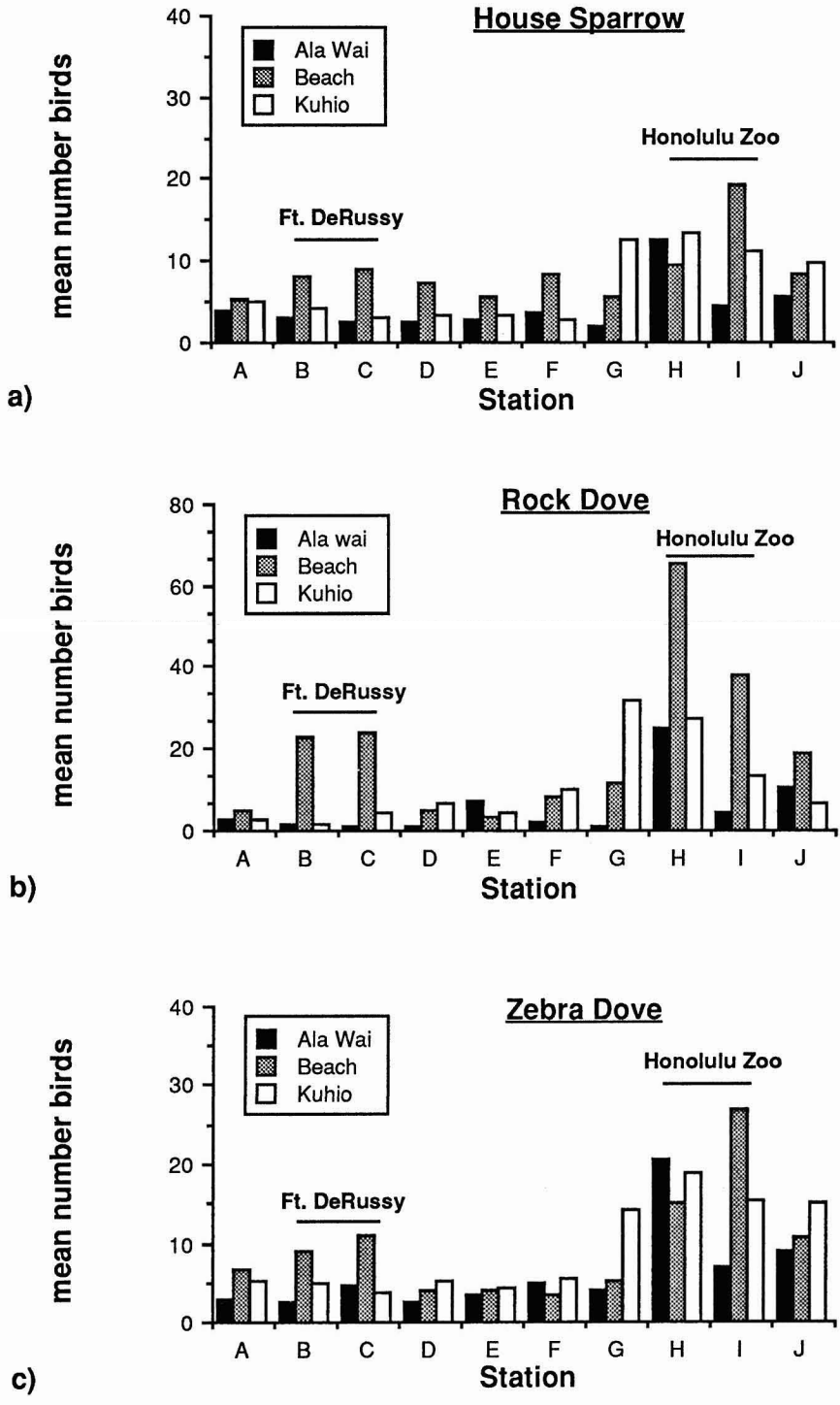

FIGURE 3. Mean number of (*a*) House Sparrows, (*b*) Rock Doves, and (*c*) Zebra Doves observed at each transect sampling location along the Ala Wai, beach, and Kuhio transects.

TABLE 1

Distance from the Honolulu Zoo, Mean Number of Birds for the Three Target Species, Habitat Scores, Human Density, and PC-1 Score for Each Station in Waikiki

			BIRDS†			HABITAT FEATURES‡									
TRANS	STA	DIST* ZOO	HS	RD	ZD	CC	BD	BH	GR	BS	SH	TR	PM	HUMAN DENSITY	PC-1 SCORE
Ala Wai	A	206	3.81	2.63	2.81	4§	3	3‖	2	0	1	2	2	1.69	0.66
Ala Wai	B	176	3.19	1.94	2.50	4	4	3	1	0	1	0	2	1.75	1.80
Ala Wai	C	150	2.56	0.88	4.50	4	4	4	2	2	1	1	4	1.38	1.97
Ala Wai	D	123	2.63	1.00	2.69	4	3	4	3	2	2	3	3	1.56	0.71
Ala Wai	E	98	2.75	7.25	3.38	4	3	3	3	1	1	1	3	1.88	0.92
Ala Wai	F	74	3.50	2.31	4.94	4	3	3	2	0	1	1	2	1.75	0.96
Ala Wai	G	52	2.00	1.31	4.00	4	3	4	4	3	2	3	3	1.50	0.63
Ala Wai	H	40	12.63	25.25	20.69	2	1	1	5	1	1	4	1	1.88	−2.09
Ala Wai	I	29	4.50	4.56	6.94	2	1	1	5	1	1	4	1	1.50	−2.39
Ala Wai	J	37	5.63	10.56	8.88	2	0	0	5	1	0	5	1	1.38	−3.19
Beach	A	196	5.39	5.13	6.61	2	3	3	2	2	0	1	2	2.35	0.77
Beach	B	173	8.04	22.70	9.09	5	1	3	3	0	0	4	3	3.13	−0.33
Beach	C	146	9.00	23.91	11.13	3	0	0	4	0	0	2	4	3.52	−1.79
Beach	D	119	7.30	4.83	3.96	2	4	2	2	2	0	1	2	3.61	0.75
Beach	E	93	5.57	3.26	4.04	3	2	3	2	4	2	3	2	3.70	0.40
Beach	F	73	8.30	8.30	3.39	4	3	3	0	3	0	2	3	3.78	1.85
Beach	G	43	5.65	11.48	5.17	4	4	4	0	1	1	1	2	3.61	2.25
Beach	H	16	9.52	65.48	15.09	4	1	3	3	1	1	3	3	3.26	−0.26
Beach	I	20	19.39	38.04	27.09	1	1	1	5	0	1	4	4	2.48	−2.81
Beach	J	54	8.44	19.04	10.65	1	1	1	5	0	0	3	5	2.17	−2.39
Kuhio	A	178	5.06	2.72	5.11	3	3	5	2	1	0	1	2	3.11	1.51
Kuhio	B	152	4.22	1.50	5.06	4	4	2	0	1	1	2	1	2.72	1.31
Kuhio	C	124	3.00	4.50	3.89	4	5	3	0	0	1	1	3	3.22	2.08
Kuhio	D	98	3.39	6.89	5.17	4	5	4	0	1	0	1	2	3.72	2.62
Kuhio	E	70	3.39	4.56	4.33	5	5	4	0	1	1	1	1	3.39	2.83
Kuhio	F	43	2.89	9.83	5.61	4	4	5	2	1	1	3	2	3.22	1.42
Kuhio	G	13	12.72	31.94	14.22	3	2	3	3	0	2	4	2	2.28	−0.90
Kuhio	H	13	13.50	27.78	18.72	2	0	1	4	0	0	4	0	2.22	−2.54
Kuhio	I	31	11.11	13.22	15.44	0	0	0	5	0	3	4	1	1.61	−3.98
Kuhio	J	57	9.89	6.89	15.06	2	0	1	5	0	3	3	0	1.39	−2.76

*One unit = 7.5 m.

†Bird codes: HS, House Sparrow; RD, Rock Dove; ZD, Zebra Dove.

‡Habitat feature codes: CC, concrete, asphalt, sand; BD, buildings; BH, building height; GR, grass; BS, bushes (<1 m ht.); SH, shrubs (1–2.5 m ht.); TR, trees (>2.5 m ht.); PM, palms.

§Habitat values: 0 = 0–5%, 1 = 6–25%, 2 = 26–50%, 3 = 51–75%, 4 = 76–95%, 5 = 96–100%.

‖Building heights: 0 = none, 1 = home, 2 = 4-story, 3 = 10-story, 4 = 20-story, 5 = >30-story.

center of the Honolulu Zoo were examined using Spearman rank correlation. Distance from the Zoo was significantly and negatively correlated ($P < 0.01$) with mean bird numbers for all three target species (Table 3).

INTERRELATIONSHIP OF HABITAT CHARACTERISTICS, HUMAN DENSITY, AND DISTANCE FROM ZOO WITH MEAN BIRD DENSITIES. Habitat features, human density, and distance from the Honolulu Zoo (Table 1) were all significantly correlated with mean bird densities (Table 3). Multiple regression procedures were utilized to reduce the confounding effects of these three factors and to clarify their individual relationships to mean bird densities (Table 4).

House Sparrow distributions were primarily influenced by habitat characteristics (Table 4). Human density played a smaller but significant role, but distance from the Honolulu Zoo did not significantly affect House Sparrow distributions (Table 4). Rock Doves occurred primarily around the Honolulu Zoo and became less common with increasing distance from the Zoo. Human density and habitat characteristics did not significantly affect Rock Dove distributions. Zebra Dove distributions were significantly related to habitat characteristics, but not to human density or distance from the Zoo (Table 4).

TABLE 2

EIGENVECTORS FOR EACH HABITAT VARIABLE ON THE FIRST THREE PRINCIPAL COMPONENTS FOR WAIKIKI DATA

HABITAT FEATURE (% VARIATION)	PC-1 (48.8%)	PC-2 (16.6%)	PC-3 (12.3%)
Concrete	0.407	0.033	−0.005
Buildings	0.472	0.028	−0.082
Building height	0.435	0.125	0.192
Grass	−0.462	−0.044	0.213
Bushes	0.200	0.229	0.749
Shrubs	−0.078	0.701	0.145
Trees	−0.400	0.172	0.253
Palms	0.037	−0.638	0.515

DISCUSSION

Distributions and Habitat Associations

Perhaps the most interesting results of this study were those from the multiple regression

TABLE 3

SPEARMAN RANK CORRELATIONS OF HUMAN DENSITY, DISTANCE FROM HONOLULU ZOO, AND HABITAT FACTORS (PC SCORES) WITH MEAN BIRD DENSITIES IN WAIKIKI

SPECIES	HUMAN DENSITY	DISTANCE FROM ZOO	HABITAT FACTORS		
			PC-1	PC-2	PC-3
House Sparrow	0.372**	−0.485*	−0.654**	−0.161	−0.061
Rock Dove	0.341**	−0.485*	−0.511*	−0.280	0.067
Zebra Dove	0.227**	−0.560*	−0.670**	−0.109	−0.011

* = $P < 0.01$; ** = $P < 0.001$.

TABLE 4

PARTIAL REGRESSION COEFFICIENTS AND SIGNIFICANCE LEVELS FOR MULTIPLE REGRESSION OF HUMAN DENSITY, DISTANCE FROM HONOLULU ZOO, AND HABITAT FACTORS (PC-1) WITH MEAN BIRD DENSITIES IN WAIKIKI

SPECIES	HUMAN DENSITY	DISTANCE FROM ZOO	HABITAT FACTORS
			PC-1
House Sparrow	0.379*	Non-sig.	−0.690**
Rock Dove	Non-sig.	−0.485*	Non-sig.
Zebra Dove	Non-sig.	Non-sig.	−0.755**

* = $P < 0.01$; ** = $P < 0.001$.

analysis of mean bird densities (Table 4). Variables entered into the equation were distance from the Zoo, human density, and habitat characteristics from the 30 transect stations in Waikiki (Table 1). This analysis allowed us to separate the effects of distance, human density, and habitat characteristics on the distributions for each of the three target species and provides insight into the habitat selection process of each species in Waikiki.

More than one factor may have been involved in concentrating Rock Doves in the vicinity of the Honolulu Zoo and Kapiolani Park. These include feeding by humans and site fidelity. Rock Doves, members of the order Columbiformes, are recognized for their homing behaviors. This strong tendency to return to the place of birth may keep both Rock Doves and Zebra Doves in the vicinity of the Honolulu Zoo. Go (1973) noted that date (*Phoenix dactylifera*) and coconut (*Cocos* spp.) palms within the Zoo were major breeding sites for Rock Doves. Additionally, many local people and tourists feed bread and grain to large flocks of Rock Doves and Zebra Doves in front of the Zoo and in the grassy areas in Kapiolani Park between Kalakaua Avenue and the beach. The birds are conditioned to feeding each day in these areas during the lunch hours (1100–1300 hours HST) and late afternoons (1600–1800 hours HST). Thus, a combination of innate homing behaviors, conditioning to regular food sources and feeding times, and abundant evening roost sites may all interact to concentrate doves in the vicinity of the Honolulu Zoo.

House Sparrow distributions were primarily affected by habitat characteristics and to a lesser degree by human density (Table 4). House Sparrow densities were highest in parkland habitats and in areas where human densities were high. Zebra Dove distributions appeared to be affected only by habitat characteristics (Table 4). Zebra Doves were most common in parkland habitats. These results are interesting in that *different* factors or combinations of factors appear to play a role in determining distributions for each of the three target species in Waikiki. Thus, Rock Doves, House Sparrows, and Zebra Doves appear to select habitat based on different factors within the urban and adjacent parkland habitats.

The species composition and habitat associations of the Waikiki avian community are representative of urban bird comunities in general. Lancaster and Rees (1977) examined a series of habitats in Toronto, Canada, that ranged from suburban residential to industrial urban. They found that numbers of birds stayed roughly even throughout the range of habitats; however, species diversity decreased with increasing urbanization. Thus, species composition changed across the range of habitat types, with House Sparrows and Rock Doves forming more than 92% of the total bird communities in commercial and industrial urban habitats.

Similar results have been obtained from studies of urban bird communities in Arizona (Emlen 1974), Chicago (Lussenhop 1977), Washington, D. C. (Williamson and DeGraaf 1981) and Vancouver, Canada (Weber 1975). In all cases, House Sparrows and Rock Doves were present and showed positive correlations with increasing human density and decreasing vegetation. Thus, habitat selection in these two species probably has an evolutionary basis and reflects their long-term commensal relationship with humans.

Management Implications

Information such as we have compiled above provides clues as to which features in the habitat are related to the distributions of specific bird species. Such information might be used to manipulate population size of those species that are determined to be pest species in a particular area. Rock Doves, House Sparrows, and Zebra Doves have all been suggested as pest species in the Waikiki area, where they are common in open-air restaurants. Additionally, their nesting activities have been implicated in property damage and increased maintenance costs to local businesses and residents (Fleischer and Williams 1987).

Should control of these three species be deemed desirable, Rock Doves appear to be the most susceptible to some form of population control. Rock Dove distributions are concentrated near the Honolulu Zoo (Figure 3*b*), which serves as the major feeding, roosting, and breeding site for Rock Doves in

Waikiki. Although we do not necessarily advocate the following, we feel that systematic and increased levels of trapping and control of Rock Doves in the vicinity of the Honolulu Zoo would probably reduce the overall population size and affect the distribution of Rock Doves in Waikiki. Numbers of Rock Doves in the Zoo and Kapiolani Park areas could be markedly decreased; however, a reduction in the Honolulu Zoo Rock Dove population would likely have little effect on Rock Doves in the urban areas of Waikiki. Rock Doves in these areas may have strong site fidelity to specific buildings (and associated roosts and breeding sites) and therefore not be affected by trapping and control of the Zoo population. We found little evidence from banded bird resightings that Rock or Zebra Doves move regularly from either the Honolulu Zoo or Kapiolani Park into urban Waikiki (see Fleischer and Williams 1987).

House Sparrow and Zebra Dove populations would probably be much more difficult to reduce or control than the Rock Dove population. Populations of both species have remained stable from 1944 to the present (Williams 1987). Additionally, their distributions are primarily determined by habitat characteristics and, in the case of House Sparrows, secondarily by human densities. These factors are not easily manipulated; consequently, we believe it would be much more difficult to reduce or control populations of House Sparrows and Zebra Doves than Rock Doves.

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LITERATURE CITED

CAUM, E. L. 1933. The exotic birds of Hawaii. Bernice P. Bishop Mus. Occas. Pap. 10, no. 9.

EMLEN, J. T. 1974. An urban bird community in Tucson, Arizona: derivation, structure, regulation. Condor 76:184–197.

FLEISCHER, R. C., and R. N. WILLIAMS. 1987. Demography and population sizes of urban birds in Waikiki Beach, Honolulu County, Hawaii. Report to Division of Forestry and Wildlife, DLNR, State of Hawaii.

———. 1988. Human and bird interactions at feeding sites in Waikiki, Hawaii. 'Elepaio 48:61–64.

GO, R. C. P. 1973. The genetics of pigeon populations on Oahu. Ph.D Dissertation, University of Hawaii, Honolulu.

HAWAII AUDUBON SOCIETY. 1975. Hawaii's Birds. 3d Printing/Revision. Hawaii Audubon Society, Honolulu.

LANCASTER, R. K., and W. E. REES. 1977. Bird communities and the structure of urban habitats. Can. J. Zool. 57:2358–2368.

LONG, J. L. 1981. Introduced birds of the world. Universe Books, New York.

LUSSENHOP, J. 1977. Urban cemetaries as bird refuges. Condor 79:456–461.

PYLE, R. L. 1986. Honolulu Christmas bird count. 'Elepaio 46:97–99.

WALKER, R. L. 1967. A brief history of exotic game bird and mammal introductions into Hawaii—with a look to the future. Pages 94–112 *in* Proc. 47th Ann. Conf. West. Assoc. State Game Fish Comm., Honolulu, Hawaii. 16–20 July 1967.

WEBER, W. C. 1975. Nest-sites of birds in residential areas of Vancouver, British Columbia. Can. Field Nat. 89:457–460.

WEBER, W. J. 1979. Health hazards from pigeons, starlings and english sparrows. Thomson Publications, Fresno, Calif.

WILLIAMS, R. N. 1987. Alien birds on Oahu: 1944–1985. 'Elepaio 47:87–92.

WILLIAMSON, R. D., and R. M. DEGRAAF. 1981. Habitat associations of ten bird species in Washington D. C. Urban Ecol. 5:125–136.